AGE COMPOSITION OF THE PACIFIC SARDINE 1932–1960

RESEARCH REPORT 53

FISH AND WILDLIFE SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

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AGE COMPOSITION OF THE PACIFIC SARDINE 1932–1960

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FISH AND WILDLIFE SERVICE
Clarence F. Pautzke, *Commissioner*

UNITED STATES DEPARTMENT OF THE INTERIOR
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ABSTRACT

Estimates of the age composition of the commercial landings of Pacific sardine (*Sardinops caerulea*) at Monterey and San Pedro for the seasons of 1938–39, 1939–40, and 1940–41 are given. A mode-subtraction method was used to make the season of 1938–39 estimates and its accuracy is discussed. Estimates for the other seasons were obtained by applying the age data collected during those seasons.

All known age-composition data for the Pacific sardine for the seasons 1932–33 through 1959–60 are presented. Estimates of year-class size in numbers of fish are given by season and port of landing.

An annotated bibliography of papers containing basic age and length data on the Pacific sardine is included.

AGE COMPOSITION OF THE PACIFIC SARDINE 1932–1960

A knowledge of the age composition of the available population is prerequisite to understanding any commercial fishery and its potentialities. The age composition of the catch is an estimate of the age composition of the population available to the fishery. The value of these age-composition data increases with each annual addition.

The purposes of this paper are threefold. I have endeavored to estimate the age composition of the Pacific sardine, *Sardinops caerulea* (Girard), catch from 1938 to 1941 at Monterey and San Pedro to make a continuous series between 1932 and 1960. Secondly, I shall review all known previous publications dealing with Pacific sardine age composition in an effort to bring this scattered material together for easy reference. Lastly, an annotated biblography of the works containing basic age and length data is presented.

AGE COMPOSITION OF THE COMMERCIAL CATCH, 1938–1941

Determining the age composition of the commercial catch of Pacific sardine, was interesting but difficult. Early attempts to determine the age of individual sardines, using configuration of scales, were inconclusive (Thompson 1926a).[1] Age composition of the landings derived by following modes in length-frequency observations was achieved to a limited degree by several workers (Higgins, 1926; Thompson, 1926b; Scofield, 1926; Clark, 1931, 1936, and 1939). In 1938, work was begun by Walford and Mosher on the validation of scales and otoliths as indicators of Pacific sardine age and growth (Walford and Mosher, 1943a, 1943b; Mosher, 1954). The results of these studies have made it possible to compute the age composition of the catch for two separate periods, 1932 to 1938 and 1941 to 1960. Age composition of the commercial catch from 1941 to 1960 has been determined by examination of scale samples from all ports of landing on the Pacific coast of the United States, Canada, and from Baja California, Mexico. Various workers have cooperated in reading scale samples. Otolith samples taken between 1932 and 1938 were examined and aged by Mosher (1954) and used by Eckles (1954) to estimate age composition of the catch for the ports of Mon-

Note.—Approved for publication, August 26, 1960. Research Report 53.

[1] All references cited in the text of this report are contained in the bibliography (p. 32 to 36).

terey and San Pedro. The results of the present study fill the intervening gap for these ports, and extend the period of known age composition for the others.

L. A. Walford and K. H. Mosher, U.S. Fish and Wildlife Service, assembled and read all the scales collected from 1938 to 1941; the California Department of Fish and Game made available length measurements and length-weight data for this period; the Fisheries Research Board of Canada made length - frequency, length - weight, and scale data available from British Columbia sardine landings. B. A. Taft, Bureau of Commercial Fisheries, and I. Yamanaka, Japan Sea Regional Fisheries Researc Laboratory, gave helpful advi and criticism on methods and ana ysis of data.

LENGTH AND SCALE SAMPLIN

Sampling of the commerci catch for length composition w carried out during the seasons 1938–39 through 1940–41 at a ports having active sardine fis eries. Length measurements we taken in accordance with t method outlined by Sette (1926 During the seasons of 1938–39 a 1939–40, length samples were take biweekly at San Pedro, Montere and San Francisco by workers

Table 1.—Fish aged and measured, by lunar month and lunar period, for all ports, season 1938–39

Port and lunar month [1]	Lunar period [2]	Number of—	
		Age readings	Fish measur
British Columbia: Summer			
Washington: Summer			
Oregon: Summer			
San Francisco:			
"August"	233		1,
"September"	234		2,
"October"	235		1,
"November"	236		1,
"December"	237		1,
"January"	238	188	1,
Total		188	9,
Monterey:			
"July"	232		
"August"	233		1,
"September"	234		1,
"October"	235		1,
"November"	236		1,
"December"	237		1,
"January"	238		1,
Total			10,
San Pedro:			
"October"	235		
"November"	236		3,
"December"	237		2,
"January"	238		2,
"February"	239		2,
"March"	240		2,
Total			13,
Grand total		188	33,

[1] Lunar months are always placed in quotation marks to distinguish them from the calendar months th approximate.

[2] Lunar periods have been numbered serially since "November" 1919. (See Scofield, 1926.)

the California Department of Fish and Game. During the 1940–41 season, the Department continued sampling fish at San Pedro and Monterey, while sampling at San Francisco was carried out by the U.S. Fish and Wildlife Service. Personnel of the Fish and Wildlife Service also sampled sardines landed during the summer fisheries in Washington and Oregon. Sampling in British Columbia was done by the personnel of the Fisheries Research Board of Canada. Individual samples taken in the United States consisted of 50 fish selected at random from the catch of 1 boat; samples taken in British Columbia consisted of 100 fish each. The number of samples taken daily was proportional to the number of landings.

Age sampling during the period 1938 to 1941 was incomplete. Most collections of scales and otoliths were made by personnel of the Fish and Wildlife Service. A few scale samples were collected in British Columbia during the summer of 1940 by personnel of the Fisheries Research Board of Canada. All of the scale samples were examined for age by Walford and Mosher. The numbers of length measurements made and scale samples read during the period 1938–39 through 1940–41 are given in tables 1 to 3.

Table 2.—Fish aged and measured, by lunar month and lunar period, for all ports, season of 1939–40

Port and lunar month [1]	Lunar period [2]	Number of—	
		Age readings	Fish measured
British Columbia: Summer			1,578
Washington: Summer		789	5,091
Oregon: Summer			1,295
Total, Pacific Northwest			7,964
San Francisco:			
"October"	247		1,250
"November"	248		1,600
"December"	249		1,600
"January"	250		250
"February"	251		1,100
Total		789	5,800
Monterey:			
"September"	246	693	1,250
"October"	247	835	1,750
"November"	248	746	2,000
"December"	249	799	1,650
"January"	250		1,350
"February"	251		1,000
Total		3,073	9,000
San Pedro:			
"November"	248		2,600
"December"	249		3,100
"January"	250	686	2,650
"February"	251		2,200
"March"	252		2,800
"April"	253		800
Total		686	14,150
Grand total		4,548	36,914

[1] Lunar months are always placed in quotation marks to distinguish them from the calendar months they approximate.

[2] Lunar periods have been numbered serially since "November" 1919. (See Scofield, 1926.)

Table 3.—Fish aged and measured, by lunar month and lunar period, for all ports, season o 1940–41

Port and lunar month [1]	Lunar period [2]	Number of—	
		Age readings	Fish measur
British Columbia: Summer		496	2,5
Washington: Summer		349	
Oregon: Summer		137	6
Total, Pacific Northwest			3,3
San Francisco:			
"August"	258		1,7
"September"	259	529	1,7
"October"	260	969	1,6
"November"	261	678	1,7
"December"	262	379	1
"January"	263	573	9
Total		3,128	7,9
Monterey:			
"September"	259		7
"October"	260	998	1,7
"November"	261		1,2
"December"	262		5
"January"	263	240	1,5
"February"	264		2
Total		1,238	6,0
San Pedro:			
"October"	260		1,3
"November"	261		3,4
"December"	262		2,0
"January"	263	762	3,0
"February"	264		2,0
"March"	265		2
Total		762	11,9
Grand total		6,110	29,1

[1] Lunar months are always placed in quotation marks to distinguish them from the calendar months the approximate.
[2] Lunar periods have been numbered serially since "November" 1919. (See Scofield, 1926.)

AGING LENGTH SAMPLES

Age Data Available

Length measurements were the only data taken regularly during the seasons 1938–39 through 1940–41. In dealing with periods for which age data were available, I considered it necessary first to age the fish in the length-frequency summaries, and from them calculate the ages of the fish in the commercial landings of the same lunar periods. The method used in applying age data to length samples was described by Eckles (1954). The assumption he has made, and with which I concur, is that the age composition of each centimeter di vision of the age sample is repre sentative of the age composition o the corresponding centimeter divi sion of the length sample. Thi method of aging the commercia catch was applied to all periods fo which age data were collected.

Age Data Incomplete

Age composition of the catch fo seasons with partial coverage b age sampling was also determine in the manner described by Eckle (1954). The characteristic fal to-winter changes in length compo sition described by Clark (1936 were not so readily apparent in th

1939–40 and 1940–41 seasons as in earlier seasons, and could not be observed at all after this period. Both Eckles and I assumed that age samples taken at a port during any lunar month of either the fall or winter periods could be projected to other lunar months of the same fall or winter period for which samples were not available.

Age Data Lacking

There were no usable random samples of scales from the commercial catch, during the 1938–39 season at either San Pedro or Monterey. Some sampling of small fish was done (Walford and Mosher, 1943a), but these samples are not usable for age determination of the commerical catch.

Fishing was sometimes carried on in a common area by the fleets of both Monterey and San Francisco during the 1938–39 season. Since some age data are available from San Francisco for this season, a survey of these data was made to determine the feasibility of using age determinations from fishing areas common to the Monterey and San Francisco fleets to age sardine landings of corresponding periods at Monterey. After I selected and summarized the scale readings from San Francisco, I found the age data insufficient to give a usable estimate of the age composition at Monterey.

Clark (1936) in her examination of monthly length frequencies, proposed that four seasonal periods—spring, summer, fall, and winter—existed in the fishery during the years she investigated. Upon examination of the length frequencies of the sardine catch at both San Pedro and Monterey, the 1938–39 season was found to contain periods which could be defined as summer, fall, and winter. Because the differences were so marked (figs. 1 and 2), I decided that any attempt to age these length frequencies must preserve the seasonal differences.

Length-frequency data for the 1938–39 season at Monterey and San Pedro were examined to see if they could be apportioned by age, using as a guide the age-length data of other seasons.

All length-frequency summaries examined had definite modes. With a reasonable knowledge of where the modes of younger ages occur, gained through examination of the length frequency of known ages in adjacent years, it was not difficult to pick out the modes of ages 0- and 1-year-old fish and, usually, 2-year-old fish. Fortunately, 1's and 2's must have been the dominant ages of the 1938–39 season at both Monterey and San Pedro. This circumstance made it possible to obtain a more reliable age composition than would have been possible had the 1938–39 season been more normal as regards age composition, i.e., had it been a season with a larger proportion of the older ages. The process by which I obtained estimates of the age composition involved the subtraction of successive modes from the length-frequency summary. The procedure followed for the fall period at Monterey is reproduced

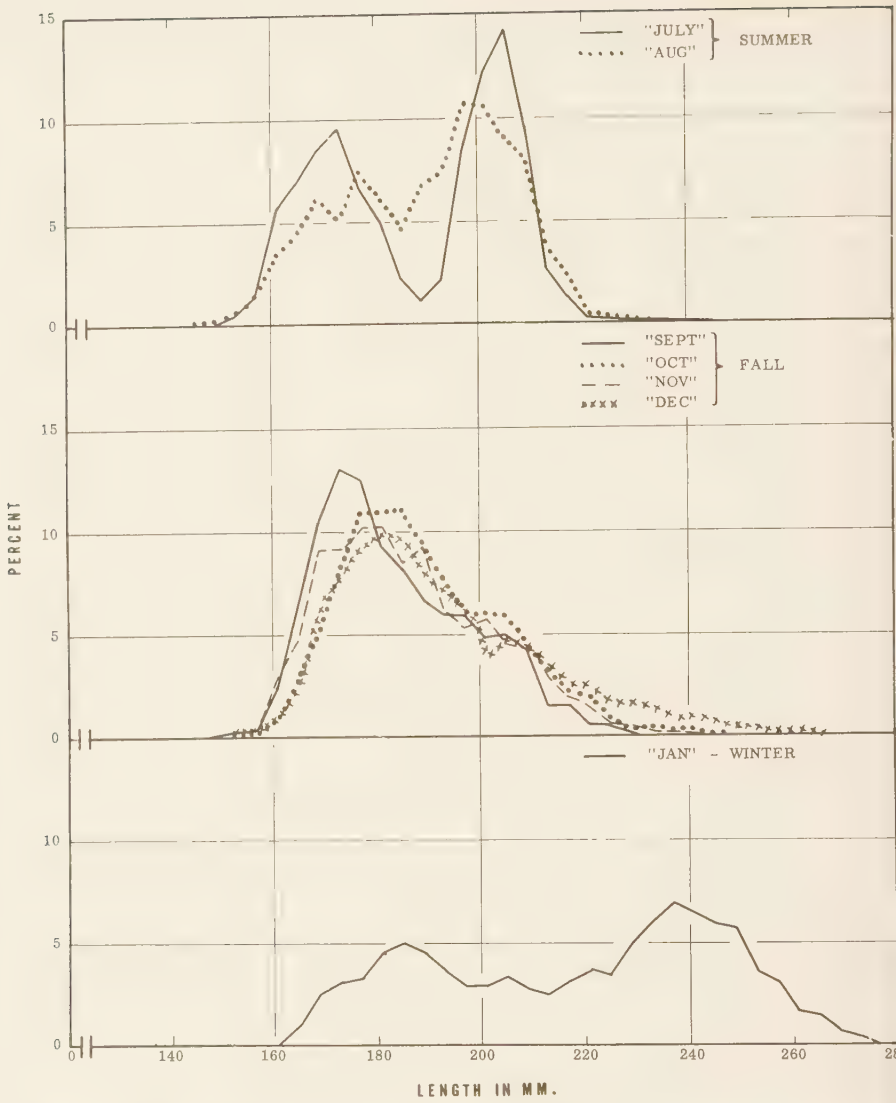

Figure 1.—Length composition, by lunar month, of the commercial sardine catch at Monterey dur ing the 1938–39 season, grouped by 4-mm. intervals.

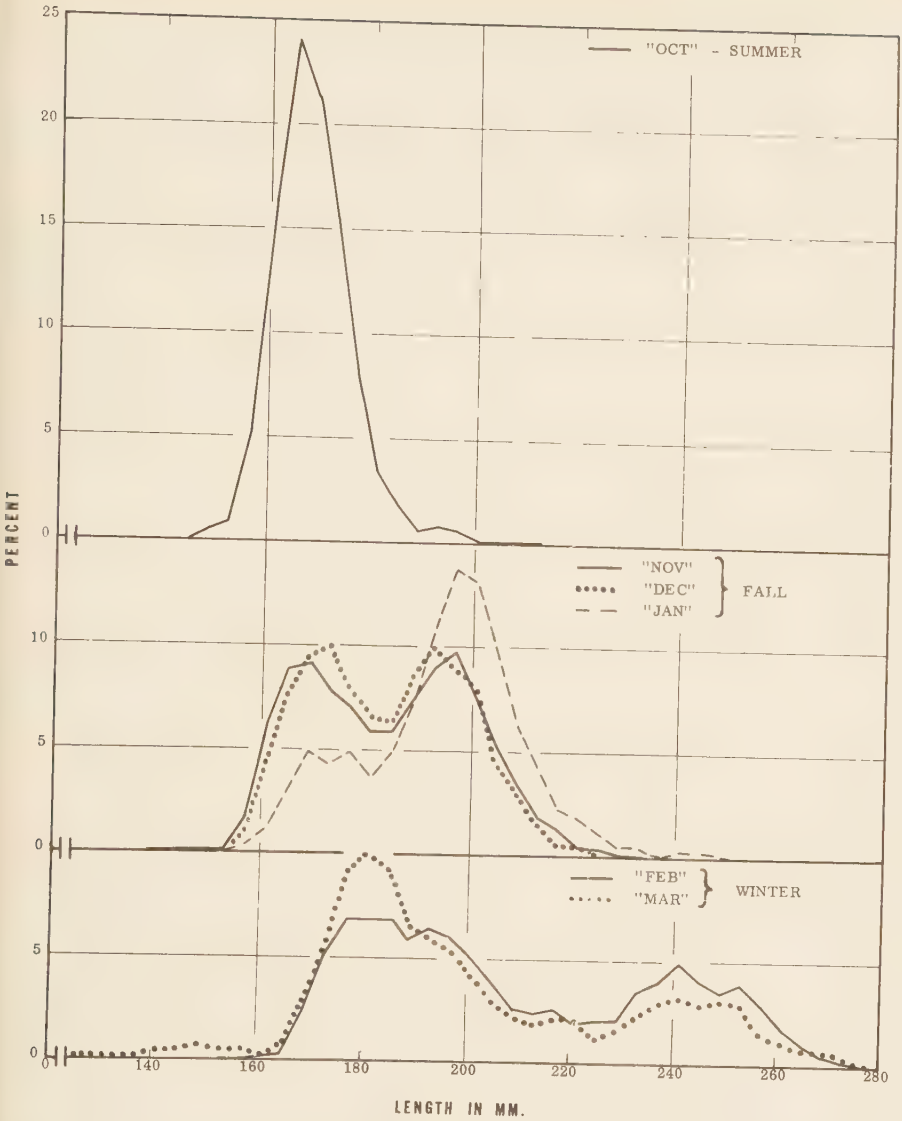

Figure 2.—Length composition, by lunar month, of the commercial sardine catch at San Pedro during the 1938–39 season, grouped by 4-mm. intervals.

Table 4.—Age composition of length-frequency samples obtained from the commercial catch o
Monterey, fall period 1938–39

[Derived by the method of mode subtraction; a–k (in parentheses), successive steps in method]

Standard length (mm.)	Total samples	Number of fish by year class and age									
		1937		1936		1935		1934		1933	
		1 year	Residual	2 years	Residual	3 years	Residual	4 years	Residual	5 years	6+ years
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
145	2	2									
149	3	3									
153	12	12									
157	43	43									
161	130	130									
165	280	280									
169	529	529									
173	649	649									
177	724	724									
181	687	649	38	38							
185	629	529	100	100							
189	565	280	285	285							
193	455	130	325	325							
197	393	43	350	350							
201	346	12	334	325	9	9					
205	340	3	337	285	52	52					
209	294	2	292	100	192	192					
213	188		188	38	150	52	98	98			
217	140		140		140	9	131	131			
221	109		109		109		109	98	11	11	
225	62		62		62		62		62	62	
229	44		44		44		44		44	11	3
233	35		35		35		35		35		
237	22		22		22		22		22		2
241	25		25		25		25		25		2
245	13		13		13		13		13		1
249	10		10		10		10		10		1
253	9		9		9		9		9		
257	5		5		5		5		5		
261	4		4		4		4		4		
265	3		3		3		3		3		
Total	6,750	4,020		1,846		314		327		84	15
Percent	100.0	59.5		27.3		4.7		4.9		1.2	2.

in table 4. The basic length-frequency data are given in column a. The primary mode appears at 177 millimeters, and it is considered to be composed primarily of 1-year-old fish, as the average of mean lengths of 1-year-old fish for 6 seasons either side of the 1938–39 season is 173 mm. The frequency distribution (column b) of 1-year-olds thus derived is identical with the frequencies of the summary distribution to the left (smaller) of the primary mode, and their mirror images to the right (larger) of the mode. This hypothetical distribution is then subtracted from the summary distribution, and th residual distribution (column c examined for its primary mode The primary mode falls at 197 mm. which corresponds satisfactorily with the average mean length of 2 year-old fish at 201 mm., calculated as 1-year-olds were previously. Th process is then repeated successively until only a small residual distribu tion remains (column k). Th totals of the age columns are used as a basis for calculating the pro portion of each age in the summary distribution. Results are shown graphically in figure 3.

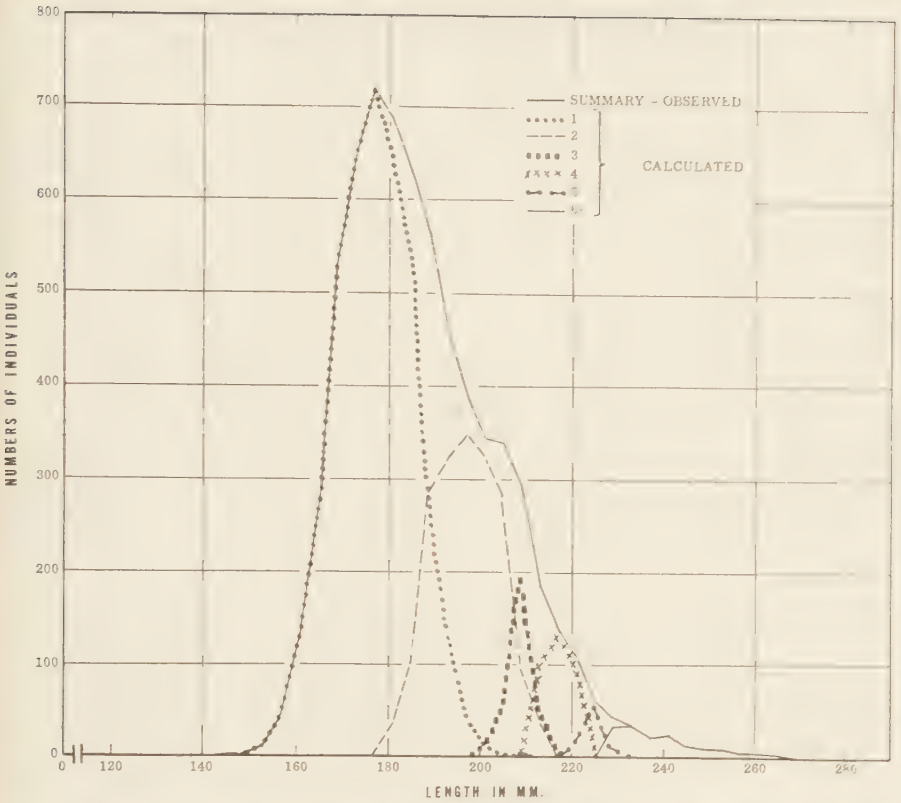

Figure 3.—Hypothetical length-frequency distributions of ages contained in the observed summary length-frequency distributions for Monterey, fall period, 1938–39 season. (Age distributions were obtained by the mode-subtraction method.)

It might be argued that a calculated symmetrical frequency-distribution curve for any given age may not represent the true form of the frequency distribution of that age. Examination of the frequency distributions of ages 1, 2, and 3 during the five seasons, starting with 1941–42 and ending with 1945–46 at Monterey, showed that all of these curves approached symmetry except those of the 1941 class, which were asymmetrical. In view of the 80-percent majority, I assumed a symmetrical curve was not only acceptable but probably the best representation of the frequency distribution of an age.

Examination of hypothetical frequency distributions of successsive ages for a given period reveals a progressively increasing beyond-modal overlap with age (fig. 4). The mode-subtraction method assumes overlap only to the center of the frequency distribution of the modal frequency. Actually, the overlap may extend beyond the modal frequency. When this situation occurs, the number of fish in the younger mode will be overestimated and the number of fish in the

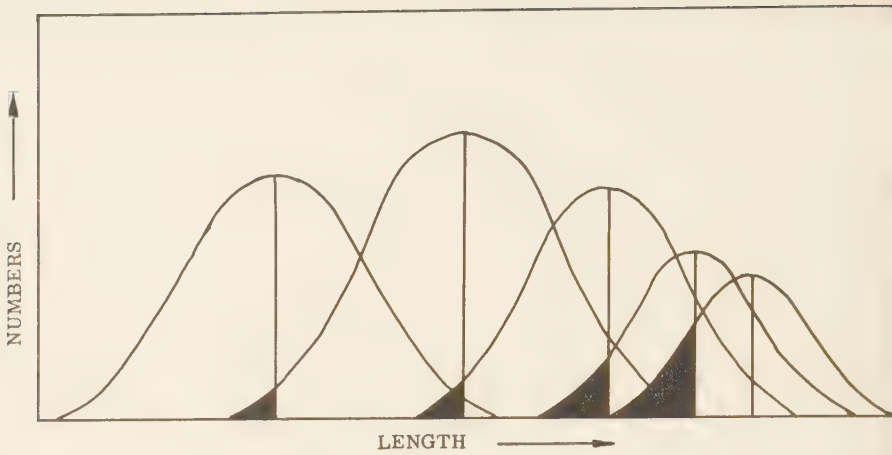

Figure 4.—Hypothetical length distribution of successive age samples in the sardine catch durin a normal season, showing beyond-modal overlap, which is disregarded by the mode-subtractio method. (Area in question is darkened.)

older mode will be underestimated. In a season where average age of the catch is normal (2–3 years), such an overlap might introduce excessive error into the computations of the number of fish in each age group. Fortunately, ages 1 and 2 predominated in the catch in the 1938–39 season, as has been previously cited. Since the length distributions of these younger ages are farther apart on the length scale than those of older ages, an attempt to estimate the beyond-modal overlap of these young ages was made. Examination of length frequency distributions of 1-, 2-, and 3-year-old fish of the 1940, 1941, and 1942 classes showed the overlap to average 4.8 percent between ages 1 and 2, 13.0 percent between ages 2 and 3, and 0.1 percent between ages 1 and 3, calculated at the intervals used as means for each of those ages. Since these margins of error are not excessive and are probably much less than the inherent error in the method, I am disregardin them. Calculations of the expecte overlap of distributions at th older ages are certainly greater i absolute degree but, relative to th numbers involved during this sea son in the younger ages, they ar actually quite small. Therefore, have also disregarded them in th calculations of numbers of each ag

I have purposely simplified the ex planation of the mode-subtractio method. The application of th method is more subjective than ha been indicated, and I have set u a hypothetical problem to illustrat several ways in which subjectivit may influence age estimation The choice of a modal value for th length-frequency distribution of a age cannot always be restricted t one individual frequency. In th example in table 5, two almo equal frequencies are used to re resent the hypothetical mode of ag n (column b).

Table 5.—Hypothetical example illustrating subjectivity in mode-subtraction method of obtaining age composition of length-frequency samples

[a–g (in parentheses), successive steps in method]

Standard length (mm.)	Total samples (a)	Age n (b)	Residual (c)	Age $n+1$ [1] (d)	Residual $c-d$ (e)	Age $n+1$ [2] (f)	Residual $c-f$ (g)
157	2	2					
161	15	15					
165	39	39					
169	48	48					
173	55	[3] 55					
177	56	[3] 56					
181	50	48	2	2		2	
185	46	39	7	7		7	
189	50	15	35	35		35	
193	59	2	57	57		57	
197	68		68	68		68	
201	79		79	79		79	
205	98		98	98		98	
209	65		65	79	−12	65	
213	60		60	68	−8	60	
217	55		55	57	−2	55	
221	50		50	35	15	35	15
225	36		36	7	29	7	29
229	20		20	2	18	2	18
233	15		15		15		15
237	12		12		12		12
241	10		10		10		10
245	5		5		5		5
249	1		1		1		1

[1] Calculated frequency distribution of age $n+1$ following basic mode-subtraction method.
[2] Calculated frequency distribution of age $n+1$ in which no value exceeds the residual in column c.
[3] These two values represent hypothetical mode of age n.

If, as in table 5 (column d) the right slope of the calculated length-distribution curve exceeds the values of the actual curve at one or more frequencies, it is impossible to obtain a positive residual. Thus, it is necessary to transform the calculated-frequency curve so that all values are less than the corresponding actual values. The symmetry of the calculated-frequency curve changes somewhat in the process (column f). The procedure is then continued as originally outlined.

The original mode-subtraction process, as applied to the fall period at Monterey (see table 4), was repeated for summer ("July" and "August") and winter ("January") at Monterey; and summer ("October"), fall ("November," "December," and "January"), and winter ("February" and "March") at San Pedro.

Frequencies in the summer period at Monterey exhibited a bimodal length distribution with a primary mode at 205 mm. and a secondary mode at 173 mm. (fig. 1). These modes were obviously made up almost entirely of 2- and 1-year-old fish, respectively. A small number of 3-year-olds was also present. The fall period at Monterey has been previously explained. During the winter months another bimodal length-frequency distribution was observed. The aging process was followed as described for younger ages, but was weighted to the 1931 and 1932 classes (ages 7 and 6). These two classes were considered superabundant in number as 3-year-olds (Eckles, 1954). The

same situation existed in the winter fishery at San Pedro that season (fig. 2), and fish used in the length-frequency summary of the winter fishery there were aged in the same way as for Monterey.

Upon reexamination, the fall period at San Pedro was found to consist of two periods: the typical fall months of "November" and "December" and a second period, "January," which was about midway between typical fall and typical winter periods. The aging process was then reapplied to each of the two periods for a more accurate age composition of the catch in the fall period.

The length-frequency distribution at San Pedro in the summer period was found to be unimodal at the 165-mm. or 1-year-old level, and thus was considered to consist almost entirely of 1-year-old fish.

The summaries of these agings gave a percentage of each age present during each period at each of the ports for a season.

Since the inaccuracies involved, especially in the older ages, can be considerable, a quantative test for amount of error that might be expected was devised. Other specific periods having a known age composition based on scale readings were re-aged using the mode-subtraction method. The results (table 6) are, as expected, reasonably accurate at younger ages and relatively inaccurate at older ages. The examples, A and B, were selected because they are similar in age composition to the 1938–39 season. Example C, taken during a season when older ages predominate, shows even less accuracy in older ages.

DETERMINING NUMBERS AT EACH AGE

With age composition for the three commercial fishing seasons, 1938–39 through 1940–41, determined as far as available scale data permit, it is then possible to compute numbers of fish at each age landed during the completed periods.

In order to age the commercial catch, it first was necessary to know

Table 6.—Observed and calculated age compositions

	Percentage by age						All ages
	1	2	3	4	5	6+	
A. San Pedro (1941–42):							
Observed	12.1	50.9	31.5	5.5			100.
Calculated	12.2	51.6	23.0	[1] 3.2			100.
B. Monterey (1939–1940):[2]							
Observed	20.7	39.2	29.9	10.2			100.
Calculated	22.0	36.9	30.6	10.5			100.
C. Monterey (1944–45):							
Observed	13.4	41.2	10.5	14.0	16.0	4.9	100.
Calculated	13.5	45.2	5.7	9.8	13.0	12.8	100.

[1] Includes 4 year-old and older fish.
[2] Fall period.

the number of fish landed during each lunar period at each port during the three seasons under study. These figures are available directly for San Pedro (Calderwood, 1953). The numbers of fish landed at Monterey were computed by using the known tonnages landed and length-weight data obtained by the California Department of Fish and Game. Numbers of fish landed at San Francisco during 1940–41 were determined by using the average number of fish per ton landed per week, based on data obtained by the Fish and Wildlife Service. Tons landed in the Pacific Northwest were converted, where necessary, to numbers of fish by applying length-weight data from British Columbia obtained by the Fisheries Research Board of Canada.

The calculated number of sardines landed each lunar period was then separated into ages in the same proportion as in the aged lunar-month length-frequency summaries. This procedure was followed for the entire 1938–39 season and the fall periods of the 1939–40 and 1940–41 seasons at San Pedro; the entire season during all 3 years at Monterey; the entire 1940–41 season at San Francisco; the 1939 and 1940 summer periods in Washington and British Columbia and the 1940 summer period in Oregon.

To complete the aging of the San Pedro catch during the 1939–40 and 1940–41 seasons, it was necessary to compute the numbers of fish at each age during winter periods from numbers at each age during fall periods. Following the method described by Eckles (1954), the ratios of fall to winter numbers at each age observed during the 1933–34 and 1934–35 seasons were used. These seasons were the only ones completely sampled that had both fall and winter fisheries. When it was necessary to calculate numbers at each age for the 6-year-old and older fish, the fall-to-winter ratio used was the mean of ratios of the 6- through 10-year-olds observed during the 1933–34 and 1934–35 seasons.

SUMMARY OF NUMBERS AT EACH AGE

All of the computations of age composition of the commercial catch of Pacific sardines possible for the three seasons, 1938–39 through 1940–41, have now been completed. While the calculated numbers of fish at each age are only approximations of the actual numbers of each age landed, they are the best estimates I have been able to obtain with the available data. More important is the fact that estimates of the age composition of the landings are now available for Monterey and San Pedro from 1932 to 1960.

The total catch in tons, total numbers, and numbers and percent of each age for San Pedro and Monterey from 1938 to 1941, Washington and British Columbia from 1939 to 1941, and San Francisco and Oregon during the 1940–41 season, are given in tables 7, 8, and 9.

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Table 7.—Age (year class) composition of the sardine catch, 1938–39 season

[Numbers of fish by age determined by mode-subtraction method]

Port	Catch		Number of fish (in thousands) by age and year class									
	Tons	Number of fish	0 (1938)	1 (1937)	2 (1936)	3 (1935)	4 (1934)	5 (1933)	6 (1932)	7 (1931)	8 (1930)	9 (1929)
SAN PEDRO:												
"October"	2,357	38,800										
Subtotal, summer	2,357	38,800		37,714	1,086							
"November"	36,285	429,000										
"December"	37,081	438,100										
Subtotal, "November" and "December"	73,366	867,100	867	345,973	518,526	[1] 1,734						
"January"	24,123	240,000		86,880	113,280	28,320	6,000	[1] 5,520				
Subtotal, fall	97,489	1,107,100	867	432,853	631,806	[1] 30,054	6,000	[1] 5,520				
"February"	31,211	240,400										
"March"	16,583	142,800										
Subtotal, winter	47,794	383,200	6,131	161,327	51,732	26,824	18,777	26,440	47,134	34,105	[1] 10,730	
Total, San Pedro	147,640	1,529,100	6,998	631,894	684,624	[1] 56,878	24,777	[1] 31,960	47,134	34,105	[1] 10,730	
Percent		100.0	0.5	41.3	44.8	3.7	1.6	2.1	3.1	2.2	0.7	
MONTEREY:												
"July"	[1] 201	1,909										
"August"	28,342	258,042										
Subtotal, summer	28,543	259,951		116,198	134,915	[1] 8,838						
"September"	26,400	267,098										
"October"	28,804	265,732										
"November"	29,136	284,837										
"December"	32,376	282,846										
Subtotal, fall	116,716	1,100,513		654,806	300,440	51,724	53,925	13,206	[1] 26,412			
"January"	34,598	214,701										
Subtotal, winter	34,598	214,701	215	29,629	34,781	22,973	14,385	15,888	53,675	25,979	9,447	[1] 7,729
Total, Monterey	179,857	1,575,165	215	800,633	470,136	[1] 83,535	68,310	29,094	[1] 80,087	25,979	9,447	[1] 7,729
Percent		100.0	0.1	50.9	29.8	5.3	4.3	1.8	5.1	1.6	0.6	0.5
GRAND TOTAL	327,497	3,104,265	7,213	1,432,527	1,154,760	[1] 140,413	93,087	[1] 61,054	[1] 127,221	60,084	[1] 20,177	[1] 7,729
PERCENT		100.0	0.2	46.2	37.3	4.5	3.0	2.0	4.1	1.9	0.6	0.2

[1] Contains some older fish.

Table 8.—Age (year class) composition of the sardine catch, 1939–40 season

Port	Catch		Number of fish (in thousands) by age and year class												
	Tons	Number of fish	1 (1938)	2 (1937)	3 (1936)	4 (1935)	5 (1934)	6 (1933)	7 (1932)	8 (1931)	9 (1930)	10 (1929)	11 (1928)	12 (1927)	13 (1926)
SAN PEDRO:															
"November" [1]	18,674	183,400	16,083	124,711	32,941	7,407	1,552	[2] 706							
"December" [1]	23,856	220,000	12,136	143,568	47,761	12,419	2,555	[2] 1,561							
"January"	22,540	214,400	16,343	142,718	39,320	10,032	2,184	[2] 3,803							
"February" [1]	15,384	142,500	14,315	83,233	27,205	9,262	1,749	[2] 6,736							
Subtotal (fall)	80,454	760,300	58,877	494,230	147,227	39,120	8,040	[2] 12,806							
"March"	10,602	86,200													
"April"	1,333	13,600													
Subtotal (winter) [3]	11,935	99,800	7,414	55,397	19,267	6,714	2,913	[2] 8,095							
Total, San Pedro	92,389	860,100	66,291	549,627	166,494	45,834	10,953	[2] 20,901							
Percent		100.0	7.7	63.9	19.4	5.3	1.3	2.4							
MONTEREY:															
"September"	23,483	190,069	21,896	96,707	57,173	12,621	1,064	456					152		
"October"	54,576	472,908	127,550	220,240	109,715	12,160	1,351	1,892							
"November"	47,251	405,414	123,043	149,192	111,894	18,041	2,027	1,014	203						
"December"	53,058	370,013	32,068	115,713	159,217	41,038	8,522	8,522	2,467	1,794	224	224	[2] 224		
"January" [4]	26,878	180,781	9,641	56,243	76,598	21,694	6,026	6,160	1,741	1,875	268	134	[2] 401		
"February" [4]	21,946	150,156	5,256	60,513	53,005	15,616	4,955	6,307	2,102	1,652	300	150	[2] 300		
Total, Monterey	227,192	1,769,341	319,454	698,608	567,602	121,170	23,945	24,351	6,513	5,321	792	508	[2] 1,077		
Percent		100.0	18.0	39.4	32.0	6.8	1.4	1.4	0.4	0.3	0.1	0.1	0.1		
Total, Monterey and San Pedro	319,581	2,629,441	385,745	1,248,235	734,096	167,004	34,898	[2] 45,252	6,513	5,321	792	508	[2] 1,077		
Percent		100.0	14.7	47.4	27.9	6.3	1.3	1.7	0.2	0.2	0.1	0.1	0.1		
WASHINGTON:															
Summer fishery	17,760	73,313	14	29	4,940	12,342	18,750	15,308	11,766	6,365	1,310	1,440	604	244	201
Percent		100.0	0.1	0.1	6.7	16.8	25.6	20.9	16.0	8.7	1.8	1.9	0.8	0.3	0.3
BRITISH COLUMBIA:															
Summer fishery [5]	5,520	23,147			1,531	3,899	6,094	4,953	3,956	1,762	346	375	130	58	43
Percent		100.0			6.6	16.8	26.3	21.4	17.1	7.6	1.5	1.6	0.6	0.3	0.2
Total, Washington and British Columbia	23,280	96,460	14	29	6,471	16,241	24,844	20,261	15,722	8,127	1,656	1,815	734	302	244
Percent		100.0	0.1	0.1	6.7	16.8	25.7	21.0	16.3	8.4	1.7	1.9	0.8	0.3	0.2
GRAND TOTAL	342,861	2,725,901	385,759	1,248,264	740,567	183,245	59,742	[2] 65,513	22,235	13,448	2,448	2,323	[2] 1,811	302	244
PERCENT		100.0	14.1	45.7	27.1	6.7	2.2	2.4	0.8	0.5	0.1	0.1	0.1	0.1	0.1

[1] Aged with "January" age composition.
[2] Contains some older ages.
[3] Numbers of fish at each age were determined by using Eckles (1954: p. 29) fall to winter ratio method.
[4] Aged with "December" age composition.
[5] Aged with Washington summer fishery age composition.

Table 9.—Age (year class) composition of the sardine catch, 1940–41 season

Port	Catch		Number of fish (in thousands) by age and year class											
	Tons	Number of fish	1 (1939)	2 (1938)	3 (1937)	4 (1936)	5 (1935)	6 (1934)	7 (1933)	8 (1932)	9 (1931)	10 (1930)	11 (1929)	12 (1928)
CALIFORNIA:														
San Pedro:														
"October" [1]	26,186	281,500	59,765	174,530	39,410	6,496	866	433						
"November" [1]	59,230	630,500	111,821	424,660	79,369	11,683	2,040	927						
"December" [1]	22,092	203,100	11,678	128,562	50,674	10,358	1,016	812						
January"	40,096	363,900	30,932	200,509	103,105	25,230	1,577	[2] 2,547						
"February" [1]	21,588	192,700	21,968	98,373	49,042	16,765	1,638	[2] 4,914						
Subtotal, fall	169,192	1,671,700	236,164	1,026,634	321,600	70,532	7,137	[2] 9,633						
"March"	266	1,700												
Subtotal, winter	266	1,700	246	950	348	101	21	[2] 34						
Total, San Pedro	169,458	1,673,400	236,410	1,027,584	321,948	70,633	7,158	[2] 9,667						
Percent		100.0	14.1	61.5	19.2	4.2	0.4	0.6						
Monterey:														
"September" [3]	15,822	128,404	19,689	70,365	31,502	5,821	856	171						
"October"	60,197	479,028	96,627	189,695	146,172	39,143	5,475	1,642		274				
"November" [3]	54,570	394,805	44,218	148,446	148,131	41,060	8,528	2,843	947	632				
"December" [3]	5,496	37,734	2,058	11,663	17,152	5,283	823	274	412	69				
"January"	26,744	186,490	16,038	59,304	77,704	24,990	3,979	2,735		870	870			
"February" [1]	1,400	11,421	91	1,325	5,299	2,878	640	503		228	[2] 457			
Total, Monterey	164,229	1,237,882	178,721	480,798	425,960	119,175	20,301	8,168	1,359	2,073	[2] 1,327			
Percent		100.0	14.4	38.9	34.4	9.6	1.6	0.7	0.1	0.2	0.1			
San Francisco:														
"August" [4]	2,991	22,641	2,557	10,441	7,805	1,438	293	27	13	67				
"September"	9,155	69,300	9,662	28,671	24,948	4,910	950	40	40	79				
"October"	60,914	454,504	77,404	153,430	165,274	47,103	9,366	551	275	551	275	275		
"November"	33,506	247,676	43,591	74,303	86,050	35,524	5,661	1,557	283	283	141	283		
"December"	1,856	14,937	398	3,386	7,467	2,987	597	100						
"January"	9,012	59,600	12,317	11,655	19,999	10,066	3,046	1,060	728	331	133	133		132
Total, San Francisco	117,434	868,658	145,929	281,886	311,545	102,028	19,913	3,335	1,339	1,311	549	691		132
Percent		100.0	16.8	32.4	35.9	11.7	2.3	0.4	0.1	0.1	0.1	0.1		0.1
Total, California	451,121	3,779,940	561,060	1,790,268	1,059,453	291,836	47,372	[2] 21,170	2,698	3,384	[2] 1,876	691		132
Percent		100.0	14.7	47.3	27.9	7.7	1.3	0.6	0.1	0.1	0.1	0.1		0.1

OREGON:													
Summer fishery	3,160	14,846		1,190	2,251	5,951	1,840	1,558	1,169	519	281	87	
Percent		100.0		8.0	15.2	40.0	12.4	10.5	7.9	3.5	1.9	0.6	
WASHINGTON:													
Summer fishery	810	3,805			439	1,537	952	512	146	146	73		
Percent		100.0			11.5	40.5	25.0	13.5	3.8	3.8	1.9		
BRITISH COLUMBIA:													
Summer fishery	28,790	135,161		421	9,155	49,771	27,253	26,937	9,944	6,051	3,788	1,578	263
Percent		100.0		0.3	6.8	36.7	20.2	19.9	7.4	4.5	2.8	1.2	0.2
Total, Pacific Northwest	32,760	153,812		1,611	11,845	57,259	30,045	29,007	11,259	6,716	4,142	1,578	87	263
Percent		100.0		1.0	7.7	37.2	19.5	18.9	7.3	4.4	2.7	1.0	0.1	0.2
GRAND TOTAL	483,881	3,933,752	561,060	1,791,879	1,071,298	349,095	77,417	[2] 50,177	13,957	10,100	[2] 6,018	2,269	87	395
PERCENT		100.0	14.3	45.4	27.1	8.9	2.0	1.3	0.4	0.2	0.1	0.1	0.1	0.1

[1] Aged with age composition of "January".
[2] Contains some older ages.
[3] Aged with age composition of "October".
[4] Aged with age composition of "September".

REVIEW OF AGE COMPOSITION, 1932–1960

Periodic summaries of previously published data are convenient for reference, especially when these data have been published in more than one series. This is such a summary of the age composition of the landings of the Pacific sardine for the seasons of 1932–33 through 1959–60.

In table 10, the contribution in numbers of each year class landed from 1924 through 1958 (complete from 1930 to 1953 only) at San Pedro and Monterey combined is presented. Also shown is the percentage relation of each year class to the largest (1939) year class. This is the longest continuous series of comparable age data available for the California sardine.

Figure 5 is a graphic presentation of the data given in table 10. The catch of fish in millions is plotted on a logarithmic scale against the seasons of catch. Each point represents the contribution to the catch of a year class during that season. When connected, the points constitute the history or "catch curve" of a year class. For example, the 1938 class appeared as 0's during the 1938–39 season. Its maximum contribution to the commercial catch was as 2's during the 1940–41 season when approximately 1½ billion fish of this year class were landed. Its last contribution was made during the 1946–47 season. Year-class summaries in numbers for all aged landings of sardines from North American Pacific coast ports from 1933 through 1957 (complete for 1940–1953 only) are presented in table 11.

Tables 12 through 22 present seasonal summaries of the catch in tons and numbers of each age for each major area of landing along the Pacific coast of North America.

The information presented in the tables and figure were obtained from publications cited as follows:

Eckles, 1954; Felin and Phillips, 1948; Felin, Phillips and Daugherty, 1949; Felin, Daugherty, and Pinkas, 1950 and 1951; Felin, Anas, Daugherty, and Pinkas, 1952; Felin, MacGregor, Daugherty, and Miller, 1953, 1954, and 1955; Felin, Wolf, Daugherty, and Miller, 1958; Mosher, Felin, and Phillips, 1949; Wolf, MacGregor, Daugherty and Miller, 1958; Daugherty and Wolf 1960; and Wolf and Daugherty (in press). Unpublished data were used from the manuscript of Gates and Wolf.[2] These references are annotated in the bibliographic section of this report. The information presented in the first part of this report is also included in this review.

[2] Gates, Doyle B., and Robert S. Wolf. Age and length composition of the sardine catch off the Pacific coast of the United States and Mexico in 1959–60. California Department of Fish and Game, State Fisheries Laboratory, Terminal Island, California. (Unpublished MS.)

Figure 5.—The commercial catch of Pacific sardine, by year classes, for Monterey and San Pedro combined, for the season 1932–33 through 1959–60. (Year class indicated on curve: 31 for 1931 class, 32 for 1932 class, and so on.)

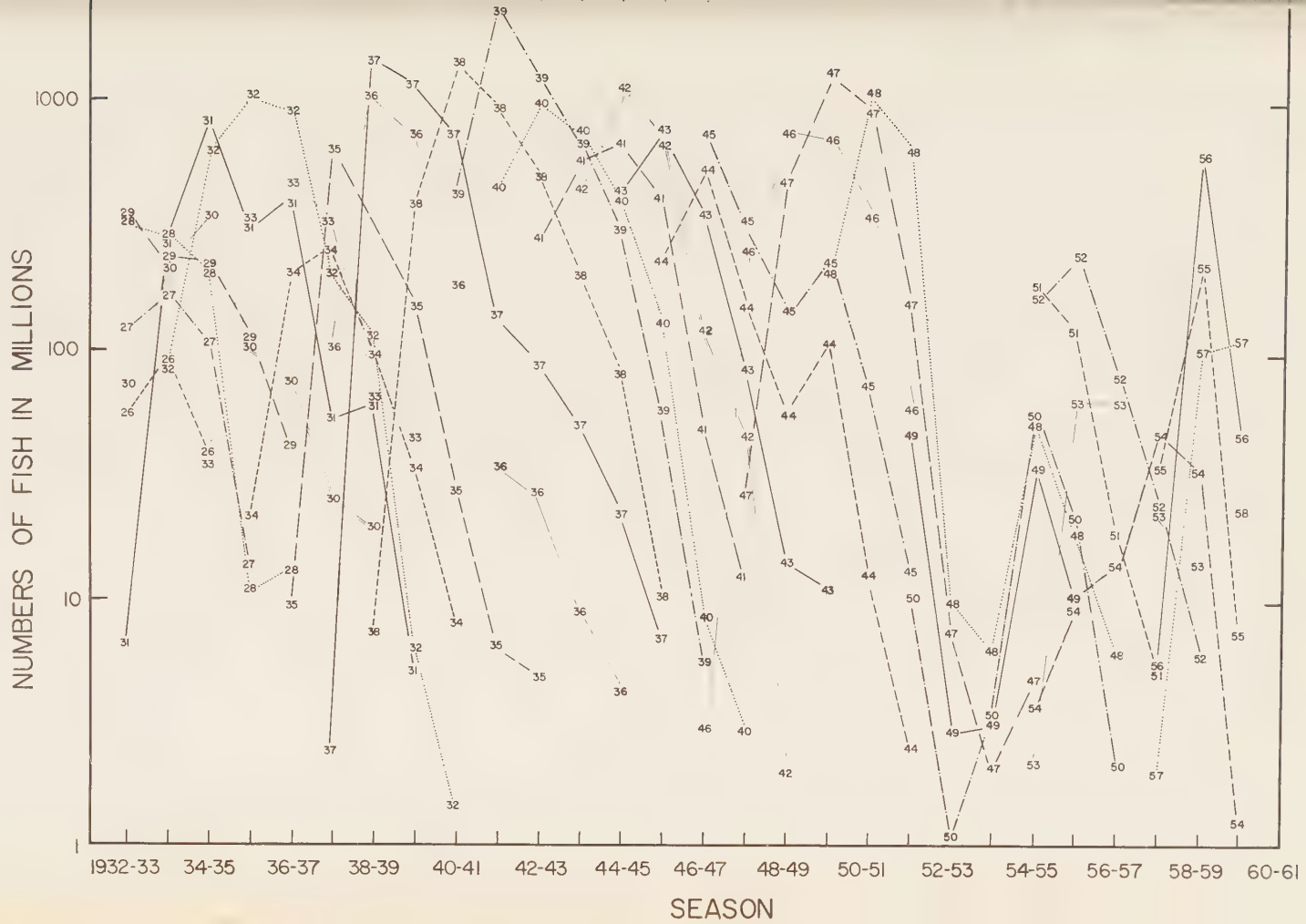
NUMBERS OF FISH IN MILLIONS
1000
100
10
1
1932-33
34-35
36-37
38-39
40-41
42-43
44-45
46-47
48-49
50-51
52-53
54-55
56-57
58-59
60-61
SEASON

Table 10.—Year-class size estimates: Number of Pacific sardines landed at Monterey and San Pedro combined, by year class and age, seasons of 1932–33 through 1959–60

Year class	Number of fish (in thousands) at age—									Total (in thousands)	Percent of largest year class (1939)
	0	1	2	3	4	5	6	7	8+ [1]		
1924									45,701		
1925								24,879	213,640		
1926							56,380	87,783	145,733		
1927						127,402	186,725	115,540	15,911		
1928					328,382	277,361	205,716	12,175	20,885		
1929				349,309	270,684	207,329	111,725	42,293	9,833		
1930			71,448	219,996	358,114	101,543	77,039	27,602	27,906	[2] 883,648	17.4
1931		6,619	271,596	858,933	331,110	395,066	54,117	60,084	7,698	1,985,223	39.1
1932		84,475	622,587	1,078,563	922,617	206,413	127,221	6,513	3,400	3,051,789	60.0
1933		36,128	335,075	470,989	314,889	61,054	45,252	1,359		1,264,746	24.9
1934		20,868	202,247	277,553	93,087	34,898	17,835	1,203		647,691	12.7
1935		9,554	639,048	140,413	167,004	27,459	6,708	4,958	2,265	997,409	19.6
1936		103,568	1,154,760	734,096	189,808	36,303	28,141	9,048	4,292	2,260,016	44.5
1937	2,597	1,432,527	1,248,235	747,908	149,039	89,594	52,494	23,232	6,947	3,752,573	73.8
1938	7,213	385,745	1,508,382	996,573	499,260	200,147	84,814	11,155	1,273	3,694,562	73.5
1939		415,131	2,249,431	1,345,525	691,028	317,459	58,393	4,512	1,484	5,082,963	100.0
1940		440,678	964,133	751,614	405,491	144,038	8,062	2,865		2,716,881	53.5
1941		277,095	570,793	691,334	413,055	47,805	12,376		1,808	2,014,266	39.6
1942		458,256	1,154,048	691,157	131,147	48,048	2,080	1,020	79	2,485,835	48.9
1943		410,923	787,319	355,107	86,666	15,529	12,791	362	274	1,668,971	32.8
1944		240,415	505,620	166,956	56,132	104,758	13,213	2,500		1,089,594	21.4
1945		741,925	306,683	158,391	214,339	70,057	14,429	337	97	1,506,258	29.6
1946	3,016	253,414	736,885	727,809	364,729	60,927	2,371	538		2,149,689	42.3
1947	27,806	490,849	1,333,226	943,924	173,589	7,421	2,092	4,905	920	2,984,732	58.7
1948	712	210,733	1,104,965	636,654	10,038	6,143	54,415	19,149	6,385	2,049,194	40.3
1949			48,729	2,832	3,286	34,763	9,860	637	574	100,681	2.0
1950		10,237	425	3,639	56,990	23,705	2,279	688	199	98,162	1.9
1951			501	193,327	131,211	19,704	5,286	1,291		351,320	6.9
1952		1,324	172,625	252,122	81,209	26,738	6,280	30		540,328	10.6
1953		2,294	67,354	65,223	26,407	15,102	191			[2] 176,571	3.5
1954	3,766	10,812	14,397	49,202	34,341	1,331				[2] 113,849	2.2
1955			35,240	224,600	15,749						
1956		5,138	622,429	109,890							
1957	1,970	102,868	165,941								
1958		24,906									

[1] Most of the estimates for this age group contain small percentages of older ages.
[2] Incomplete.

Table 11.—Year-class size estimates: Number of Pacific sardines landed at all ports sampled, by year class and age, seasons of 1941–42 through 1959–60

Year class	Number of fish (in thousands) at age—									Total (in thousands)	Percent of largest year class (1939)
	0	1	2	3	4	5	6	7	8+ [1]		
1933									17,665		
1934								24,026	5,592		
1935							48,093	14,764	15,178		
1936						184,164	79,992	44,397	19,575		
1937					444,679	210,500	148,305	73,018	18,991		
1938				1,659,267	764,652	425,332	237,637	54,174	6,378		
1939			3,196,264	1,905,673	1,228,483	654,824	145,166	23,414	10,246	[2] 7,164,070	100.0
1940		466,347	1,077,434	1,031,034	641,564	233,519	34,893	11,890	6,800	3,503,481	48.9
1941		284,812	596,690	757,265	482,284	56,203	17,576	3,284	3,063	2,201,168	30.7
1942		476,616	1,260,979	857,579	142,242	55,217	7,292	1,106	79	2,801,110	39.1
1943		431,106	923,619	369,018	95,986	21,181	12,857	362	274	1,854,403	25.9
1944		247,930	520,171	171,949	59,480	111,136	15,654	2,560		1,128,880	15.8
1945		762,109	314,161	164,152	225,782	73,960	14,580	339	102	1,555,185	21.7
1946	3,056	259,203	759,362	768,542	388,376	61,649	2,882	570		2,243,640	31.3
1947	28,448	499,860	1,416,150	989,773	176,752	10,451	2,790	5,615	978	3,130,817	43.7
1948	721	215,496	1,121,365	713,264	42,054	26,284	60,778	19,589	7,461	2,207,012	30.8
1949			60,103	17,086	6,822	41,089	10,121	908	574	137,144	1.9
1950		12,308	3,844	20,413	67,971	24,269	2,901	755	199	132,660	5.4
1951		732	3,428	217,543	134,613	23,306	5,509	1,291		[2] 386,422	8.1
1952		1,538	193,331	257,647	96,635	28,135	6,280	30		[2] 583,596	2.7
1953		2,804	68,855	76,303	28,454	15,297	191			[2] 191,904	2.7
1954	3,766	10,968	16,931	56,407	35,599	1,614				[2] 125,285	1.7
1955			11,071	236,123	16,861						
1956		19,521	708,357	131,339							
1957	2,621	115,859	238,057								
1958		48,628									

[1] 8 years and older.
[2] Incomplete.

Table 12.—Age composition of Pacific sardine catch from British Columbia ports, seasons of 1934, 1935, and 1939 through 1947

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1934	43,000	179,108				831	5,536	25,192	45,123	32,942	17,439	15,780	16,333	9,689	5,814	4,429
1935	45,320	185,195				1,329	5,760	19,938	31,900	48,291	29,241	20,823	8,862	10,189	4,874	3,988
1936 [1]																
1937 [1]																
1938 [1]																
1939	5,520	23,147				1,531	3,899	6,094	4,953	3,956	1,762	346	375	130	58	43
1940	28,790	135,161			421	9,155	49,771	27,253	26,937	9,944	6,051	3,788	1,578		263	
1941	60,460	406,000		3,695	94,273	52,496	113,518	87,655	29,597	14,413	6,658	2,964		731		
1942	65,880	365,000		3,248	45,698	170,272	56,575	50,042	27,740	6,534	3,248	548		1,095		
1943	83,740	425,000		1,870		55,292	178,330	91,970	62,135	24,225	7,437	2,465	638	638		
1944	53,380	268,100		7,105	18,794	10,161	59,411	103,594	47,212	13,700	6,086	1,528		509		
1945	34,300	146,400		1,962	14,245	18,666	2,459	32,911	46,672	22,106	5,900	1,479				
1946	3,990	15,820				1,186	1,977	989	5,142	6,328	198					
1947	485	1,891			19		284	322	113	567	454	113	19			

[1] No data.

Table 13.—Age composition of Pacific sardine catch from Washington ports, seasons of 1939 through 1947

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1939	17,760	73,313		14	29	4,940	12,342	18,750	15,308	11,766	6,365	1,310	1,440	604	244	201
1940	810	3,805				439	1,537	952	512	146	146	73				
1941	17,090	151,500		4,287	59,600	22,801	32,739	16,711	6,772	4,287	2,712	455	909	227		
1942	570	3,150			230	2,526	230	98	66							
1943	10,540	54,023		783		9,395	27,401	12,528	3,133	783						
1944	20	63		2	4	2	14	24	11	3	2	1				
1945	2,390	10,868				988	495	3,128	4,446	1,317	494					
1946	6,140	28,108				891	2,679	3,123	12,716	6,470	1,338	891				
1947	1,356	5,719				193	771	964	514	1,350	1,542	385				

Table 14.—Age composition of Pacific sardine catch from Oregon ports, seasons of 1940 through 1948

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1940	3,160	14,846			1,190	2,251	5,951	1,840	1,558	1,169	519	281		87		
1941	16,500	147,200		3,179	85,243	27,011	16,413	10,584	1,060	1,590	1,060			1,060		
1942	1,880	10,429			760	8,365	760	326	218							
1943	1,820	9,310		135		1,619	4,722	2,159	540	135						
1944 [1]																
1945	90	409				37	19	118	167	49	19					
1946	3,910	17,999				570	1,715	2,000	8,143	4,143	857	571				
1947	6,926	29,578		828		580	6,049	4,641	4,224	7,042	5,303	828	83			
1948	5,500	22,281			118	234	1,524	5,161	5,160	3,284	4,808	1,876	116			

[1] No fishery.

Table 15.—Age composition of Pacific sardine catch from all Pacific Northwest ports, seasons of 1934, 1935, and 1939 through 1948

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1934	[1] 43,000	179,108				831	5,536	25,192	45,123	32,942	17,439	15,780	16,333	9,689	5,814	4,429
1935	[1] 45,320	185,195				1,329	5,760	19,938	31,900	48,291	29,241	20,823	8,862	10,189	4,874	3,988
1936 [2]																
1937 [2]																
1938 [2]																
1939	[3] 23,280	96,460		14	29	6,471	16,241	24,844	20,261	15,722	8,127	1,656	1,815	734	302	244
1940	32,760	153,812			1,611	11,845	57,259	30,045	29,007	11,259	6,716	4,142	1,578	87	263	
1941	94,050	704,700		11,161	239,116	102,308	162,670	114,950	37,429	20,290	10,430	3,419	909	2,018		
1942	68,330	378,579		3,248	46,688	181,163	57,565	50,466	28,024	6,534	3,248	548		1,095		
1943	96,100	488,333		2,788		66,306	210,453	106,657	65,808	25,143	7,437	2,465	638	638		
1944	53,400	268,163		7,107	18,798	10,163	59,425	103,618	47,223	13,703	6,088	1,529		509		
1945	36,780	157,677		1,962	14,245	19,691	2,973	36,157	51,285	23,472	6,413	1,479				
1946	14,040	61,927				2,647	6,371	6,112	26,001	16,941	2,393	1,462				
1947	8,767	37,188		828	19	773	7,104	5,927	4,851	8,959	7,299	1,326	102			
1948	[4] 5,500	22,281			118	234	1,524	5,161	5,160	3,284	4,808	1,876	116			

[1] Data from British Columbia only.
[2] No data.
[3] Data from British Columbia and Washington only.
[4] Data from Oregon only.

Table 16.—Age composition of Pacific sardine catch from San Francisco, seasons of 1940–41 through 1950–51

Season	Catch		Number of fish (in thousands) at age—												
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12
1940–41	117, 434	868, 658		145, 929	281, 886	311, 545	102, 028	19, 913	3, 335	1, 339	1, 311	549	691		132
1941–42	185, 945	1, 439, 892		12, 559	699, 552	555, 369	132, 363	32, 719	3, 908	2, 533	889				
1942–43	115, 633	729, 592		992	56, 686	369, 563	204, 669	70, 015	23, 721	3, 245	701				
1943–44	125, 883	716, 793		11, 479	16, 524	206, 065	323, 263	117, 720	29. 826	10, 181	1, 735				
1944–45	136, 319	693, 381		9, 391	80, 978	48, 065	173, 847	232, 546	105, 390	38, 014	7, 150				
1945–46	83, 422	452, 304		5, 459	121, 753	146, 514	66, 121	53, 284	35, 476	19, 546	3, 135	1, 016			
1946–47	2, 843	17, 526		3, 789	2, 864	3, 581	2, 287	1, 210	664	1, 921	47	1, 163			
1947–48	376	[1] 3, 326		656	1, 256	663	383	249	105		4		10		
1948–49	1, 369	[1] 14, 086	[1] 9	6, 568	5, 497	1, 426	456	118	12						
1949–50	17, 535	118, 796		1, 624	70, 532	31, 390	8, 902	5, 093				965		290	
1950–51	12, 726	70, 009			6, 552	37, 423	20, 468	3, 258	2, 308						
1951–52 [2]															

[1] Includes Sacramento.
[2] No fishery.

Table 17.—Age composition of Pacific sardine catch from Monterey, seasons of 1932–33 through 1959–60

Season	Catch		Number of fish (in thousands) at age —													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1932–33	90,339	494,520			35,908	130,600	136,296	82,894	43,969	20,724	17,784	12,203	6,562	5,174	1,175	[1]1,231
1933–34	152,162	829,160		10,268	140,816	131,329	149,874	138,975	95,557	43,344	28,873	21,882	19,441	18,809	13,523	[1]16,469
1934–35	230,579	1,375,680		29,143	332,183	490,847	188,982	113,151	103,987	45,943	17,776	12,079	14,092	9,441	9,828	[1]8,228
1935–36	184,152	1,112,370		20,868	159,417	501,328	229,682	72,969	107,748	12,175	8,183					
1936–37	205,584	1,266,590		9,554	188,868	288,040	430,078	228,081	67,259	33,825	14,229		6,656			
1937–38	104,540	[1]726,920	1,042	54,857	290,954	136,565	93,960	90,464	25,887	23,926		6,132	3,153			
1938–39	179,857	1,575,165	215	800,633	470,136	[2]83,535	68,310	29,094	[2]80,087	25,979	9,447	[2]7,729				
1939–40	227,192	1,769,341		319,454	698,608	567,602	121,170	23,945	24,351	6,513	5,321	792	508	[2]1,077		
1940–41	164,229	1,237,882		178,721	480,798	425,960	119,175	20,301	8,168	1,359	2,073	[1]1,327				
1941–42	249,156	2,362,148		252,464	1,462,555	531,852	91,889	19,324	3,046	1,018						
1942–43	182,070	1,332,369		48,090	257,318	673,626	270,105	59,180	20,169	3,881						
1943–44	211,318	1,492,966		266,413	106,665	401,704	503,332	160,533	43,859	8,195	1,101	1,164				
1944–45	234,099	1,648,516		219,855	699,326	170,017	215,997	246,978	72,442	19,847	4,054					
1945–46	142,212	892,793		49,138	258,988	321,429	141,491	64,999	42,695	10,401	3,652					
1946–47	24,904	[3]171,080	2,373	72,384	21,806	34,193	19,552	11,550	5,310	3,878	34					
1947–48	11,638	[3]113,010		57,633	32,211	10,805	6,099	4,229	1,557		310	166				
1948–49	34,705	[3]425,367	712	387,079	33,140	3,743	373	320								
1949–50	128,412	937,304		16,908	628,716	189,941	60,303	30,585	8,594	449	1,808					
1950–51	32,077	200,622			37,424	78,638	66,961	11,517	5,641	362	60		19			
1951–52	15,734	102,586		6,100	5,154	43,375	23,006	21,009	3,501	441						
1952–53	44	231			5	38	97	71	15	5						
1953–54 [4]																
1954–55	830	5,207			173	2,048	1,215	937	834							
1955–56 [4]																
1956–57 [5]	62	361			28	133	148	37	3		12					
1957–58 [4]																
1958–59	24,614	271,914		29,367	193,332	48,321	771	81	42							
1959–60	15,418	115,943			44,208	62,859	8,338	507	31							

[1] Number differs from those of same period previously published by Eckles (1954) due to error in original summation.
[2] Includes some older fish.
[3] Includes fish taken from local area only.
[4] No fishery.
[5] Data from this season and following seasons published as Central California.

Table 18.—Age composition of Pacific sardine catch from San Pedro, seasons of 1932–33 through 1959–60

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1932–33	83,492	515,600	-------	6,619	35,540	218,709	192,086	44,508	12,411	4,155	1,112	460	-------	-------	-------	-------
1933–34	124,950	783,100	-------	74,207	130,780	88,667	120,810	138,386	91,168	44,439	25,117	20,300	19,280	9,071	10,639	10,236
1934–35	178,755	1,174,400	-------	6,985	290,404	368,086	169,132	94,178	101,729	69,597	20,822	12,724	9,621	10,279	9,533	11,310
1935–36	138,333	894,600	-------	-------	175,658	577,235	101,428	28,574	3,977	-------	7,728	-------	-------	-------	-------	-------
1936–37	137,911	874,100	-------	-------	13,379	182,949	492,539	166,985	9,780	8,468	-------	-------	-------	-------	-------	-------
1937–38	109,015	908,700	1,555	48,731	348,094	140,988	220,929	115,949	28,230	3,676	548	-------	-------	-------	-------	-------
1938–39	147,640	1,529,100	6,998	631,894	684,624	[1] 56,878	24,777	[1] 31,960	47,134	34,105	[1] 10,730	-------	-------	-------	-------	-------
1939–40	92,389	860,100	-------	66,291	549,627	166,494	45,834	10,953	[1] 20,901	-------	-------	-------	-------	-------	-------	-------
1940–41	169,458	1,673,400	-------	236,410	1,027,584	321,948	70,633	7,158	[1] 9,667	-------	-------	-------	-------	-------	-------	-------
1941–42	148,765	1,517,787	-------	188,214	786,876	464,721	57,150	16,979	3,662	185	-------	-------	-------	-------	-------	-------
1942–43	201,332	1,876,337	-------	229,005	706,815	671,899	229,155	30,414	7,972	1,077	-------	-------	-------	-------	-------	-------
1943–44	134,917	1,242,679	-------	191,843	464,128	349,910	187,696	39,614	8,635	853	-------	-------	-------	-------	-------	-------
1944–45	177,901	1,443,077	-------	191,068	454,722	521,317	189,494	70,481	12,373	3,385	238	-------	-------	-------	-------	-------
1945–46	172,056	1,459,686	-------	191,277	528,331	369,728	271,564	79,039	15,698	754	3,295	-------	-------	-------	-------	-------
1946–47	195,505	[2] 1,627,387	643	669,541	483,814	320,914	111,595	36,255	2,752	634	1,239	-------	-------	-------	-------	-------
1947–48	95,711	[2] 793,288	27,806	195,781	274,472	156,151	80,567	43,819	10,819	2,865	980	28	-------	-------	-------	-------
1948–49	120,630	[2] 1,035,211	-------	103,770	703,745	154,648	55,759	15,209	2,080	-------	-------	-------	-------	-------	-------	-------
1949–50	184,957	1,669,180	-------	193,825	704,510	537,868	154,036	74,173	4,197	571	-------	-------	-------	-------	-------	-------
1950–51	302,814	2,296,707	-------	-------	1,067,541	865,286	297,768	58,540	7,572	-------	-------	-------	-------	-------	-------	-------
1951–52	110,068	844,753	-------	4,137	43,575	593,279	150,583	39,918	10,928	2,059	274	-------	-------	-------	-------	-------
1952–53	4,449	23,193	-------	-------	420	2,794	9,941	7,350	2,356	332	-------	-------	-------	-------	-------	-------
1953–54	2,856	17,620	-------	1,324	501	3,639	3,286	6,143	2,092	538	97	-------	-------	-------	-------	-------
1954–55	65,918	517,878	3,766	2,294	172,452	191,279	55,775	33,826	53,581	4,905	-------	-------	-------	-------	-------	-------
1955–56	73,257	515,133	-------	10,812	67,354	252,122	131,211	23,705	9,860	19,149	460	460	-------	-------	-------	-------
1956–57 [3]	32,586	189,473	-------	-------	14,369	65,090	81,061	19,667	2,276	637	6,301	72	-------	-------	-------	-------
1957–58	21,107	151,243	1,970	5,138	35,240	49,202	26,407	26,738	5,286	688	427	147	-------	-------	-------	-------
1958–59	78,007	735,196	-------	73,501	429,097	176,279	33,570	15,021	6,238	1,291	-------	199	-------	-------	-------	-------
1959–60	29,335	202,095	-------	24,906	121,733	47,031	7,411	824	160	30	-------	-------	-------	-------	-------	-------

[1] Contains some older fish.
[2] Numbers include fish previously reported as Monterey-southern California.
[3] Data from this season and following seasons published as Southern California.

Table 19.—Age composition of Pacific sardine catch from San Diego, seasons of 1941–42 through 1954–55

Season	Catch		Number of fish (in thousands) at age—												
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12
1941–42	1,540	15,978		1,949	8,165	5,017	607	192	48						
1942–43	2,848	26,542		3,477	9,927	9,422	3,158	425	106	27					
1943–44	2,690	25,264		4,093	9,373	7,049	3,739	808	177	25					
1944–45	2,764	22,831		3,685	7,155	7,703	2,801	1,201	210	69	7				
1945–46	945	802		94	302	217	135	40	12	1	1				
1946–47	4,757	39,564	40	16,395	11,687	7,683	2,437	1,076	166	40	40				
1947–48	2,413	17,864	642	4,305	6,203	3,557	1,833	993	244	66	21				
1948–49	2,940	25,187		2,443	16,862	4,101	1,368	373	40						
1949–50	3,211	28,852		3,139	12,392	9,343	2,541	1,285	66	86					
1950–51	2,931	22,231			9,848	8,426	3,179	645	133						
1951–52	1,343	10,074		141	393	6,558	2,146	625	151	60					
1952–53	27	143			3	20	62	44	12	2					
1953–54	316	2,305		214	76	521	430	839	188	32	5				
1954–55	510	3,983		26	1,375	1,435	381	223	490	53					

Table 20.—Age composition of Pacific sardine catch from California ports, seasons of 1932–33 through 1959–60

[Only ports included for which age-composition data were available]

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1932-33	173, 831	1, 010, 120		6, 619	71, 448	349, 309	328, 382	127, 402	56, 380	24, 879	18, 896	12, 663	6, 562	5, 174	1, 175	1, 231
1933-34	277, 112	1, 612, 260		84, 475	271, 596	219, 996	270, 684	277, 361	186, 725	87, 783	53, 990	42, 182	38, 721	27, 880	24, 162	26, 705
1934-35	409, 334	2, 550, 080		36, 128	622, 587	858, 933	358, 114	207, 329	205, 716	115, 540	38, 598	24, 803	23, 713	19, 720	19, 361	19, 538
1935-36	322, 485	2, 006, 970		20, 868	335, 075	1, 078, 563	331, 110	101, 543	111, 725	12, 175	15, 911					
1936-37	343, 495	2, 140, 690		9, 554	202, 247	470, 989	922, 617	395, 066	77, 039	42, 293	14, 229		6, 656			
1937-38	213, 555	[1] 1, 635, 620	2, 597	103, 568	639, 048	277, 553	314, 889	206, 413	54, 117	27, 602	548	6, 132	3, 153			
1938-39	327, 497	3, 104, 265	7, 213	1, 432, 527	1, 154, 760	[2] 140, 413	93, 087	[2] 61, 054	[2] 127, 221	60, 084	[2] 20, 177	[2] 7, 729				
1939-40	319, 581	2, 629, 441		385, 745	1, 248, 235	734, 096	167, 004	34, 898	[2] 45, 252	6, 513	5, 321	792	508	[2] 1, 077		
1940-41 [3]	451, 121	3, 779, 940		561, 060	1, 790, 268	1, 059, 453	291, 836	47, 372	[2] 21, 170	2, 698	3, 384	[2] 1, 876	691		132	
1941-42	585, 406	5, 335, 805		455, 186	2, 957, 148	1, 556, 959	282, 009	69, 214	10, 664	3, 736	889					
1942-43	501, 883	3, 964, 840		281, 564	1, 030, 746	1, 724, 510	707, 087	169, 034	51, 968	8, 230	701					
1943-44	474, 808	3, 477, 702		473, 828	596, 690	964, 728	1, 018, 030	318, 675	82, 497	19, 254	2, 836	1, 164				
1944-45	551, 083	3, 807, 805		423, 999	1, 242, 181	747, 102	582, 139	551, 206	190, 414	59, 315	11, 449					
1945-46	398, 635	2, 805, 585		245, 968	909, 374	837, 888	479, 311	197, 362	93, 881	30, 702	10, 083	1, 016				
1946-47	228, 009	1, 855, 557	3, 056	762, 109	520, 171	366, 371	135, 871	50, 091	8, 892	6, 473	1, 360	1, 163				
1947-48	110, 138	927, 488	28, 448	258, 375	314, 142	171, 176	88, 882	49, 290	12, 725	2, 931	1, 315	194	10			
1948-49	159, 644	1, 499, 851	721	499, 860	759, 244	163, 918	57, 956	16, 020	2, 132							
1949-50	334, 115	2, 754, 132		215, 496	1, 416, 150	768, 542	225, 782	111, 136	12, 857	1, 106	1, 808	965		290		
1950-51	350, 548	2, 589, 569			1, 121, 365	989, 773	388, 376	73, 960	15, 654	362	60		19			
1951-52	127, 145	957, 413		10, 378	49, 122	643, 212	175, 735	61, 552	14, 580	2, 560	274					
1952-53	4, 520	23, 567			428	2, 852	10, 100	7, 465	2, 383	339						
1953-54	3, 172	19, 925		1, 538	577	4, 160	3, 716	6, 982	2, 280	570	102					
1954-55	67, 258	527, 068	3, 766	2, 320	174, 000	194, 762	57, 371	34, 986	54, 905	4, 958						
1955-56	73, 257	515, 133		10, 812	67, 354	252, 122	131, 211	23, 705	9, 860	19, 149	460	460				
1956-57	22, 648	189, 834			14, 397	65, 223	81, 209	19, 704	2, 279	637	6, 313	72				
1957-58	21, 107	151, 243	1, 970	5, 138	35, 240	49, 202	26, 407	26, 738	5, 286	688	427	147				
1958-59	102, 621	1, 007, 110		102, 868	622, 429	224, 600	39, 341	15, 102	6, 280	1, 291		199				
1959-60	35, 753	318, 038		24, 906	165, 941	109, 890	15, 749	1, 331	191	20						

[1] Number differs from that of same period previously published by Eckles (1954).
[2] Includes some older fish.
[3] Total number prior to this season does not include San Francisco landings.

Table 21.—Age composition of Pacific sardine catch from Baja California, Mexico, seasons of 1951–52 through 1959–60

Season [1]	Catch		Number of fish (in thousands) at age—												
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12
1951–52	8,867	84,077		1,930	10,981	70,052	1,017	97							
1952–53	6,701	53,821		732	3,416	14,234	31,954	2,986	499						
1953–54	6,852	42,022			2,851	16,253	3,106	19,302	510						
1954–55	8,707	65,829		484	19,331	22,781	10,600	6,103	5,873	657					
1955–56	1,707	11,907		156	1,501	5,525	3,402	564	261	440	29	29			
1956–57	5,971	34,611			2,534	11,080	15,426	3,602	622	271	1,041	35			
1957–58	2,513	31,804	651	14,383	5,831	7,205	2,047	1,397	223	67					
1958–59	7,793	111,895		12,991	85,929	11,523	1,258	195							
1959–60	8,113	118,672		23,722	72,116	21,449	1,102	283							

[1] Identical with San Pedro seasons.

Table 22.—Age composition of Pacific sardine catch from Pacific coast ports, seasons of 1932–33 through 1959–60

[Only ports included for which age-composition data were available]

Season	Catch		Number of fish (in thousands) at age—													
	Tons	Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
1932–33	173,831	1,010,120		6,619	71,448	349,309	328,382	127,402	56,380	24,879	18,896	12,663	6,562	5,174	1,175	1,231
1933–34	277,112	1,612,260		84,475	271,596	219,996	270,684	277,361	186,725	87,783	53,990	42,182	38,721	27,880	24,162	26,705
1934–35	452,334	2,729,188		36,128	622,587	859,764	363,650	232,521	250,839	148,482	56,037	40,583	40,046	29,409	25,175	23,967
1935–36	367,805	2,192,165		20,868	335,075	1,079,892	336,870	121,481	143,625	60,466	45,152	20,823	8,862	10,189	4,874	3,988
1936–37	343,495	2,140,690		9,554	202,247	470,989	922,617	395,066	77,039	42,293	14,229		6,656			
1937–38	213,555	[1] 1,635,620	2,597	103,568	639,048	277,553	314,889	206,413	54,117	27,602	548	6,132	3,153			
1938–39	327,497	3,104,265	7,213	1,432,527	1,154,760	[2] 140,413	93,087	[2] 61,054	[2] 127,221	60,084	[2] 20,177	[2] 7,729				
1939–40	342,861	2,725,901		385,759	1,248,264	740,567	183,245	59,742	[2] 65,513	22,235	13,448	2,448	2,323	[2] 1,811	302	244
1940–41	483,881	3,933,752		561,060	1,791,879	1,071,298	349,095	77,417	[2] 50,177	13,957	10,100	[2] 6,018	2,269	87	395	
1941–42	679,456	6,040,505		466,347	3,196,264	1,659,267	444,679	184,164	48,093	24,026	11,319	3,419	909	2,018		
1942–43	570,213	4,343,419		284,812	1,077,434	1,905,673	764,652	210,500	79,992	14,764	3,949	548		1,095		
1943–44	570,908	3,966,035		476,616	596,690	1,031,034	1,228,483	425,332	148,305	44,397	10,273	3,629	638	638		
1944–45	604,483	4,075,968		431,106	1,260,979	757,265	641,564	654,824	237,637	73,018	17,537	1,529		509		
1945–46	435,415	2,963,262		247,930	923,619	857,579	482,284	233,519	145,166	54,174	16,496	2,495				
1946–47	242,049	1,917,484	3,056	762,109	520,171	369,018	142,242	56,203	34,893	23,414	3,753	2,625				
1947–48	118,905	964,676	28,448	259,203	314,161	171,949	95,986	55,217	17,576	11,890	8,614	1,520	112			
1948–49	165,144	1,522,132	721	499,860	759,362	164,152	59,480	21,181	7,292	3,284	4,808	1,876	116			
1949–50	334,115	2,754,132		215,496	1,416,150	768,542	225,782	111,136	12,857	1,106	1,808	965		290		
1950–51	350,548	2,589,569			1,121,365	989,773	388,376	73,960	15,654	362	60		19			
1951–52	136,012	1,041,490		12,308	60,103	713,264	176,752	61,649	14,580	2,560	274					
1952–53	11,221	77,388		732	3,844	17,086	42,054	10,451	2,882	339						
1953–54	10,024	61,947		1,538	3,428	20,413	6,822	26,284	2,790	570	102					
1954–55	75,965	592,897	3,766	2,804	193,331	217,543	67,971	41,089	60,778	5,615						
1955–56	74,964	527,040		10,968	68,855	257,647	134,613	24,269	10,121	19,589	489	489				
1956–57	38,619	224,445			16,931	76,303	96,635	23,306	2,901	908	7,354	107				
1957–58	23,620	183,047	2,621	19,521	41,071	56,407	28,454	28,135	5,509	755	427	147				
1958–59	110,414	1,119,005		115,859	708,357	236,123	35,599	15,297	6,280	1,291		199				
1959–60	43,866	436,710		48,628	238,057	131,339	16,851	1,614	191	30						

[1] Number differs from that of same period previously published by Eckles (1954).

[2] Includes some older fish.

DISCUSSION

From the 1934–35 season through the 1945–46 season, more than 400,000 tons of sardines were landed annually at California ports. The three seasons for which age data are estimated in this report (1938–39 through 1940–41) are in the middle of this important period. Furthermore, the commercial catch of 670,530 tons in 1938–39 was the third largest on record, exceeded only by the catch of 791,310 tons in 1935–36 and of 680,370 tons in 1941–42. The age composition of the commercial catch in 1938–39 proved the most difficult to estimate and for this reason is probably less accurate than those of the other two seasons, especially in the older ages.

The age-composition estimate for Monterey in 1939–40 is probably quite accurate; that for San Pedro inaccurate. The availability of age samples for only 1 lunar month at San Pedro, but for a group of months at Monterey accounts for this difference. The estimate for the Pacific Northwest is probably accurate.

The accuracy of the 1940–41 estimates of age composition of the catch varies from good at San Francisco and the Pacific Northwest to fair at Monterey, to relatively poor at San Pedro; again the inaccuracy at San Pedro resulted from age sampling being limited to only 1 lunar month over the entire season.

Despite the limitations of these estimates, they are the best available. Year-class catch curves of Monterey and San Pedro show remarkable regularity in the period between 1935 and 1950. They display just as marked irregularity before and after that period.

SUMMARY

Length sampling of the commercial catch of Pacific sardine (*Sardinops caerulea*) was carried on at San Pedro and Monterey during the 1938–39 season. Length and limited age sampling was carried on at San Pedro and Monterey during the seasons of 1939–40 and 1940–41. Length and age samples were also taken at San Francisco during the 1940–41 season and in the Pacific Northwest during the summers of 1939 and 1940.

A mode-subtraction method was used to age the length samples of the 1938–39 season. The procedure involved the removal of succesive modes (age classes) from the length-frequency summaries.

The sardine catch in each of the remaining seasons was aged by applying the readings of the incomplete scale sampling to the length-frequency summary of the corresponding time period and also to those summaries of adjacent periods with similar length composition but which were not sampled for age.

Numbers of fish of each age were obtained by applying the age proportions of the summarized length frequencies to the calculated numbers of fish landed during the corresponding time period.

When necessary, numbers of fish of each age in the winter period were obtained from the numbers of

each age in the fall period by using ratios derived from similarly related periods observed during earlier seasons.

Tables are presented showing the catch of fish in tons and in numbers of fish of each age for all those ports sampled during the 1938–39, 1939–40, and 1940–41 seasons.

Year-class totals in numbers of fish and their breakdown by age are presented for the ports of Monterey and San Pedro combined from 1930 to 1955, and for all major ports of landing combined from 1939 to 1955.

A group of tables is presented which shows the catch in tons and numbers of each age in the catch for all major ports of the sardine fishery from the 1932–33 to the 1959–60 seasons.

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We believe that to be most useful a summative study, such as that presented here, should contain a list of pertinent reference works. The following list of publications contains basic age and length information on the Pacific sardine *Sardinops caerulea*. Annotations are concerned only with age and length information, and they may not at times be the main topic of the cited publication.

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